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(71) Applicant(s):
Halliburton Energy Services, Inc.
(Incorporated in USA - Delaware)
P.O. Box 819052, Dallas, Texas 75381-9052,
United States of America

(72) Inventor(s):
Ray C Smith
Neil Hepburn

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(54) Abstract Title: **Method of sealing connection between lateral borehole and main wellbore**

(57) A method of forming a connection between first and second tubular strings (112, 120) downhole. The method comprises the steps of: installing the first tubular string (112) in a first wellbore; conveying the second tubular string (120) into the first tubular string (112); displacing the second tubular string (120) through a window (118) formed through a sidewall of the first tubular string (112); displacing a structure (132) through an opening (124) in a sidewall of the second tubular string (120) into the first tubular (112); and sealing the structure between the two tubulars (112, 120). There may be a sealing material or a bonding material between the structure and strings where they are joined; the sealing may include crimping of the structure. The structure may be sealed to a deflection device (128) within the first tubular (112).

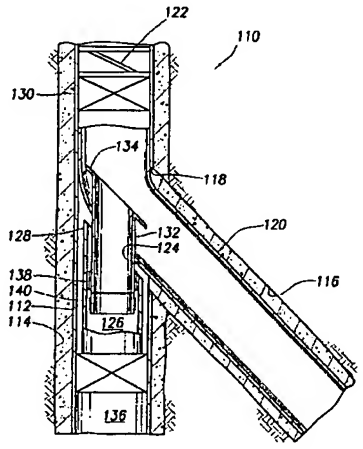

FIG.6A

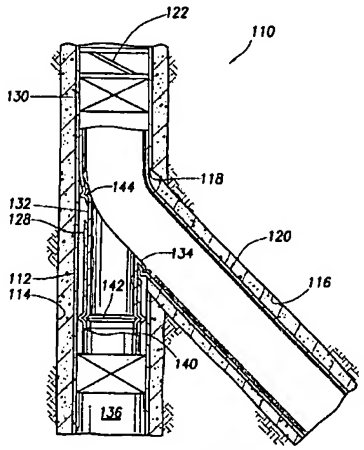

FIG.6B

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(74) Agent and/or Address for Service:
A A Thornton & Co
235 High Holborn, LONDON, WC1V 7LE,
United Kingdom

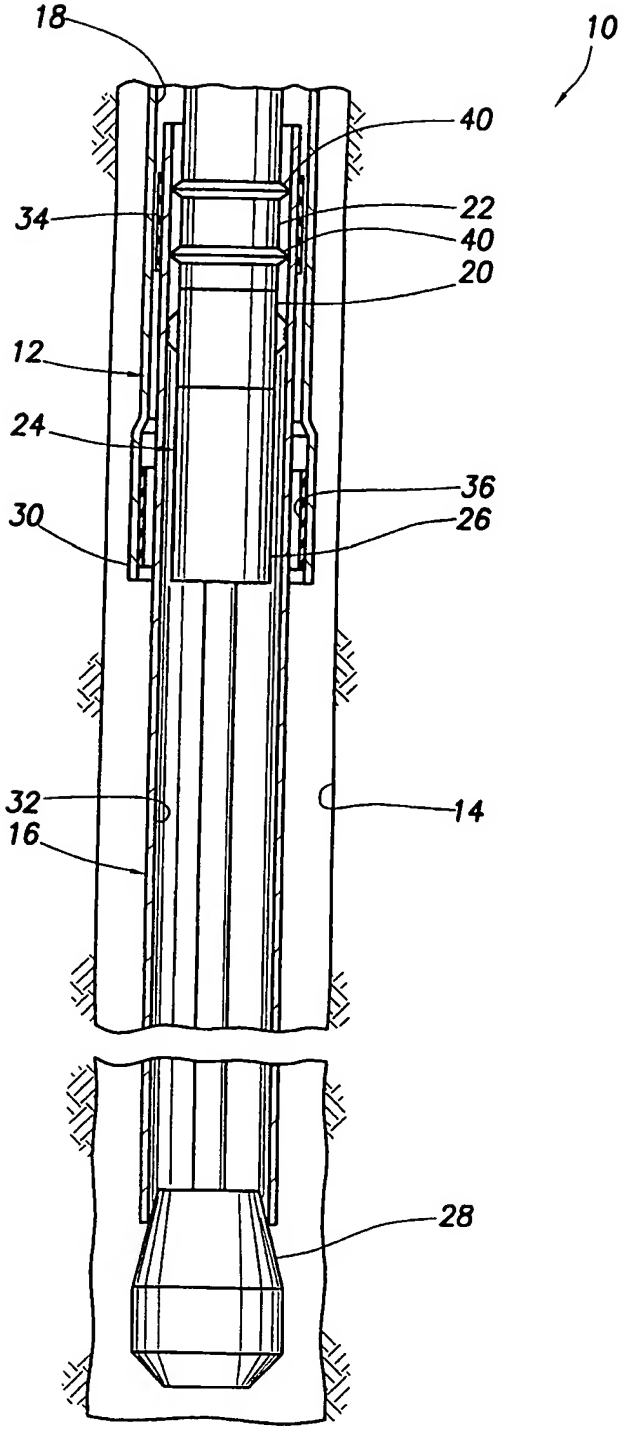

FIG. 1

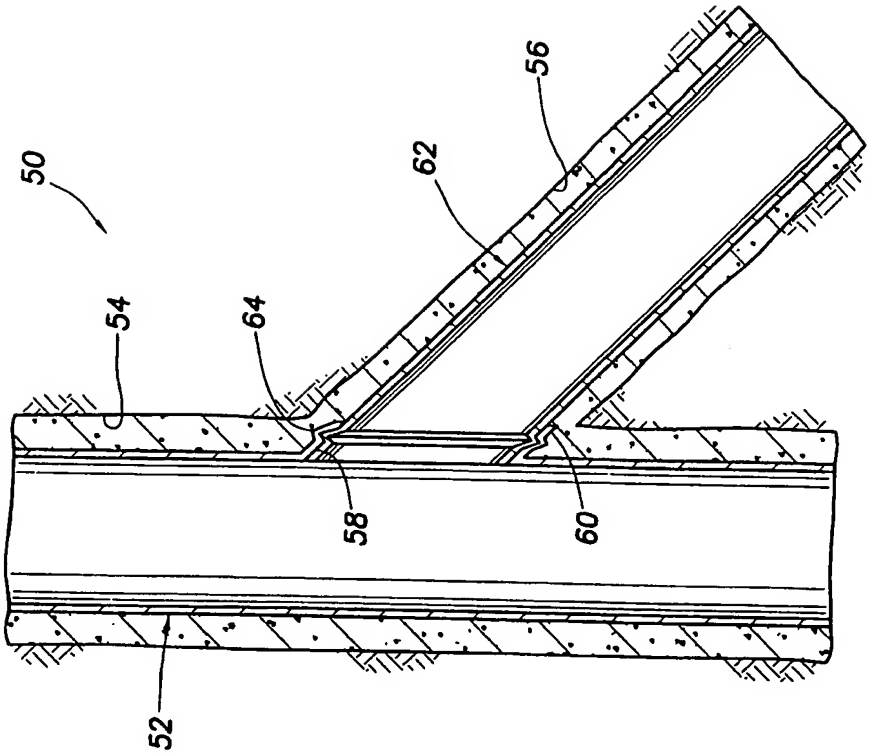

FIG.3

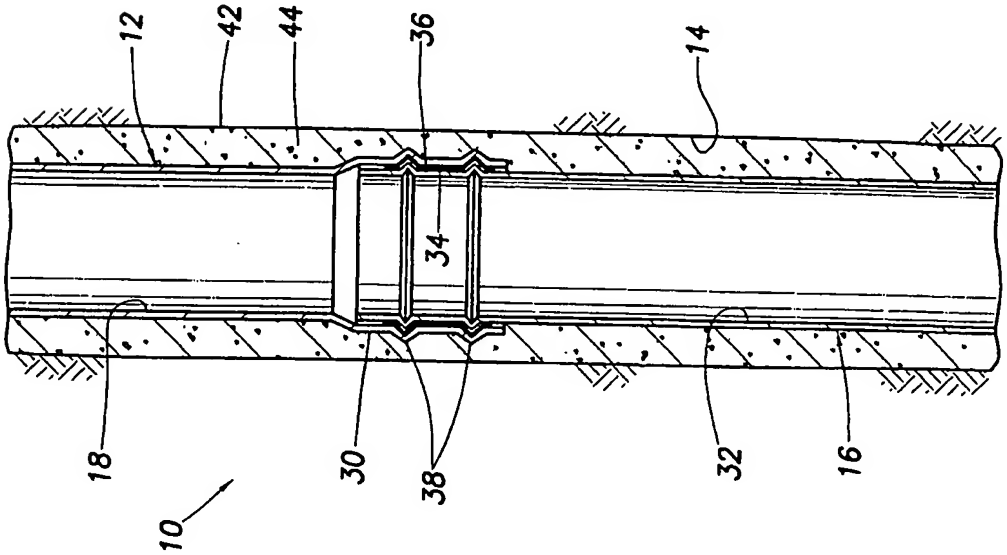

FIG.2

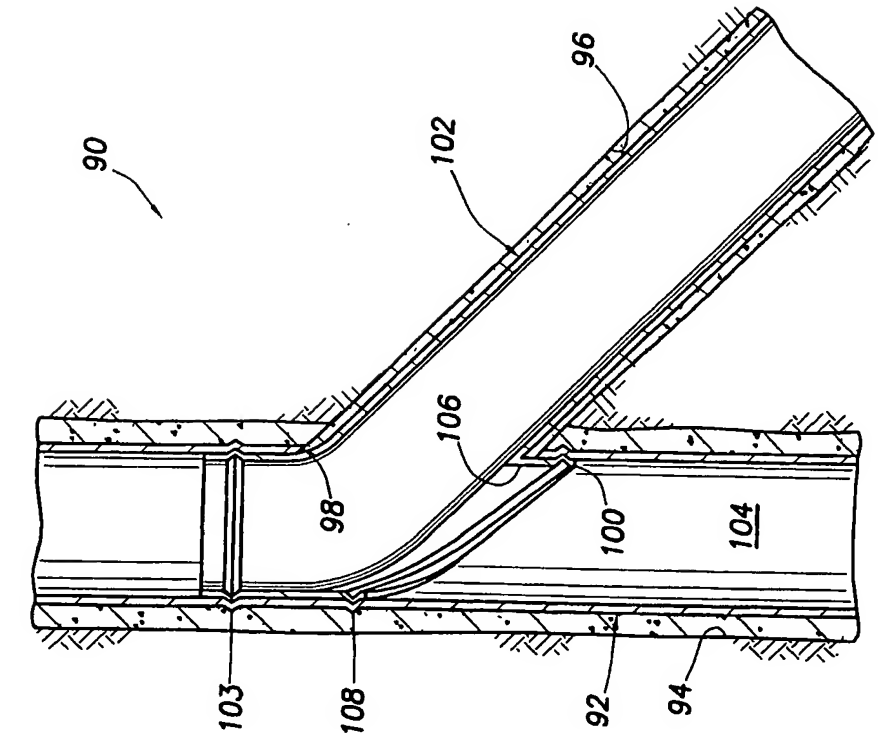

FIG.5

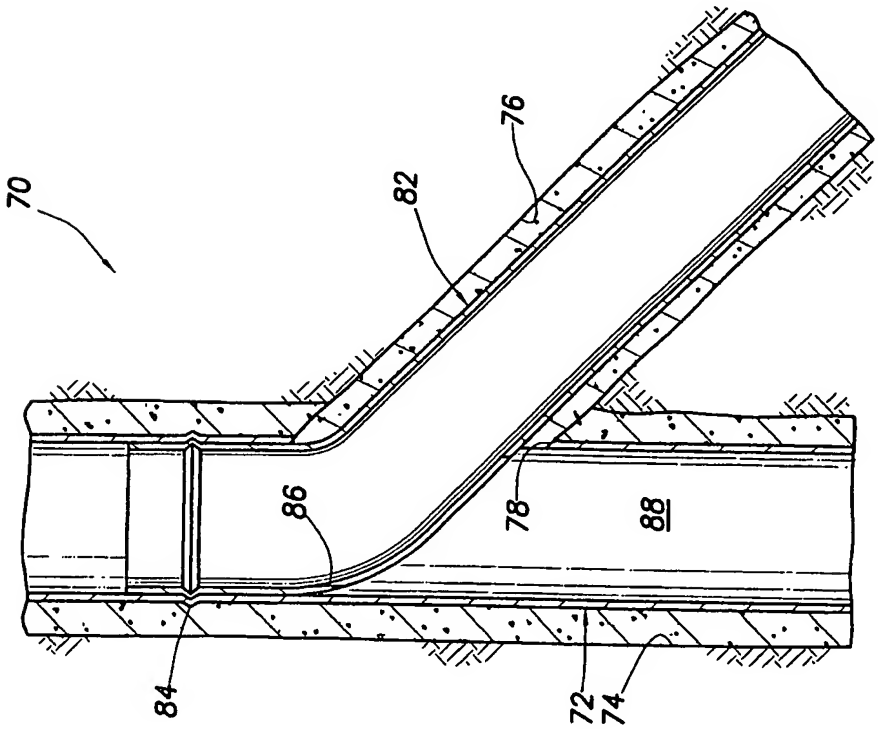

FIG.4

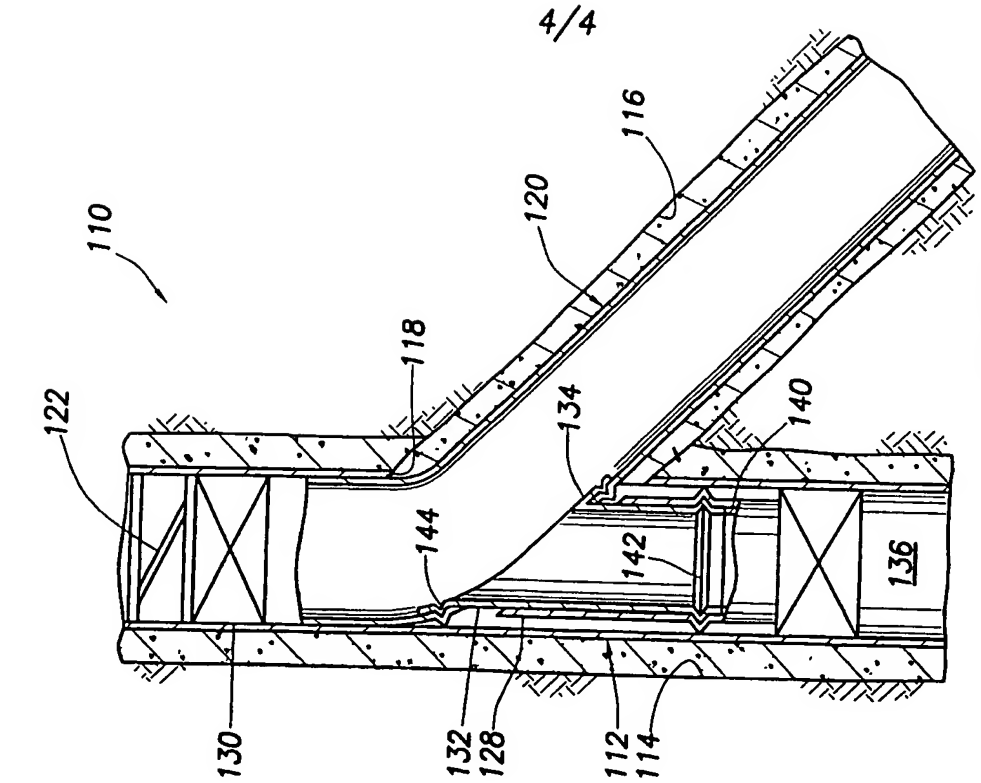
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FIG.6B

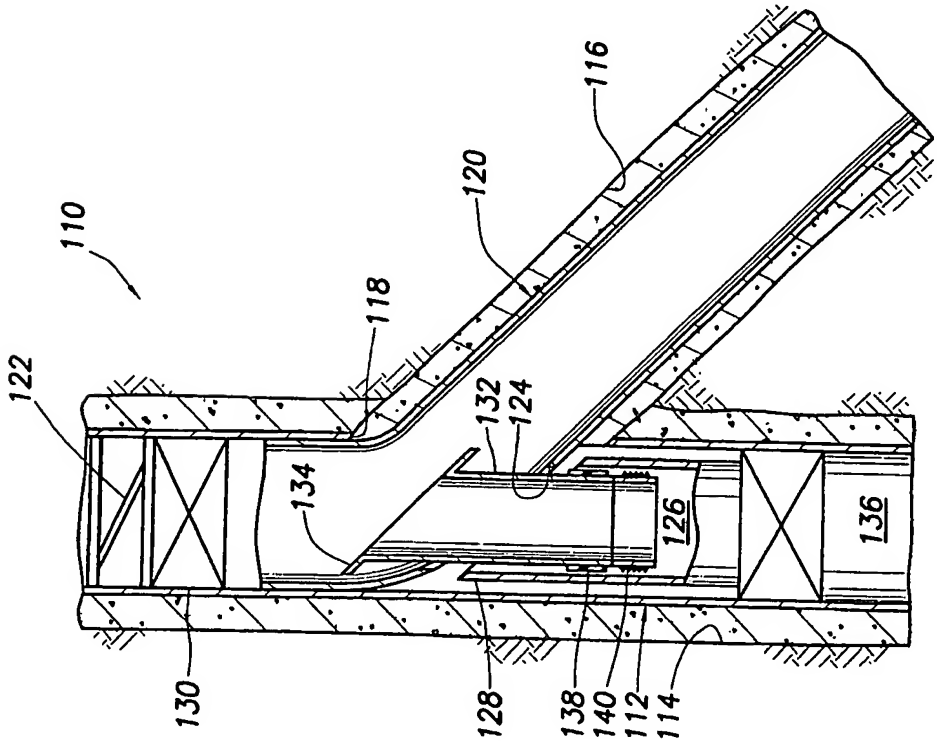
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FIG.6A

DOWNHOLE TUBULAR STRING CONNECTIONS

The present invention relates generally to operations performed in conjunction with subterranean wells, and, more particularly relates to a method of forming connections between tubular strings downhole.

It is common practice to use a packer or other anchoring device, such as a liner hanger, to secure a liner to a casing string downhole. However, the use of such anchoring devices unduly restricts access and fluid flow through the casing. In addition, these conventional anchoring devices are costly and sometimes difficult to set in certain circumstances.

Some anchoring devices, such as packers, also provide sealing between the liner and the casing. However, this sealing engagement requires a substantial amount of annular space between the liner and the casing, to accommodate the mechanical setting apparatus of a typical packer. Thus, the liner drift diameter must be substantially less than the casing drift diameter.

Furthermore, conventional anchoring devices cannot be used with expandable tubular strings, such as casings or liners which are expanded downhole. For example, a typical packer is not designed to be expanded outward along with the tubular string in which it is interconnected.

From the foregoing, it can be seen that it would be quite desirable to provide an improved method of forming connections between tubular strings downhole, which method overcomes some or all of the above described deficiencies in the art.

The present invention provides a method as recited in the appended independent claim 1. Further features of the invention are provided as recited in any of the appended dependent claims.

In carrying out the principles of the present invention, in accordance with an embodiment thereof, a method is provided for connecting tubular strings downhole. The method does not require the use of packers or other anchoring devices, yet the method secures the tubular strings to each other and provides a seal between the tubular strings.

A method is described below which includes the steps of installing a first tubular string in a wellbore, conveying a second tubular string into the first tubular string and then crimping the tubular strings to each other. The step of crimping the tubular strings

together may form a metal to metal seal between the tubular strings. Alternatively, a sealing material may be positioned between the tubular strings. The sealing material may be compressed between the tubular strings in the crimping step.

The first and second tubular strings may be bonded to each other downhole. For example, a bonding agent, such as an adhesive, may be used between the tubular strings. The bonding agent may also serve to seal between the tubular strings. The bonding agent may be compressed between the tubular strings in the crimping step.

The second tubular string may be displaced through a window formed through a sidewall of the first tubular string. The crimping step may be performed on a portion of the second tubular string which remains within the first tubular string. The crimping step may be performed on an end of the second tubular string positioned at the window. The crimping step may be performed on a portion of the second tubular string extending laterally across a longitudinal bore of the first tubular string.

The second tubular string may be expanded within the first tubular string. The first tubular string may also be an expandable string. Preferably, the first and second tubular strings have substantially equal inner drift diameters after the connection is formed between the tubular strings.

Also described hereinafter is a method of forming a connection between first and second tubular strings downhole, the method comprising the steps of: installing the first tubular string in a first wellbore; conveying the second tubular string into the first tubular string; and then crimping the first and second tubular strings together, thereby securing the second tubular string to the first tubular string, wherein in the crimping step, the second tubular string may be positioned completely within the first wellbore.

Also, in the crimping step, at least a portion of the second tubular string may be positioned within a second wellbore intersecting the first wellbore. Preferably, in the crimping step, inner drift diameters of the first and second tubular strings are substantially equal adjacent the connection.

The method may further comprise the step of positioning a sealing material between the first and second tubular strings prior to the crimping step. In the sealing material positioning step, the sealing material may be a resilient material. In the sealing material positioning step, the sealing material may be an elastomer. In the sealing material positioning step, the sealing material may be an adhesive. In the sealing material positioning step, the sealing material may be a bonding agent.

Ideally, the sealing material is carried on the first tubular string prior to the sealing material positioning step.

Alternatively, the sealing material is carried on the second tubular string prior to the sealing material positioning step. The crimping step may further comprise compressing the sealing material between the first and second tubular strings.

Also, the method may further comprise the step of positioning a bonding agent between the first and second tubular strings, and wherein the crimping step further comprises utilizing the bonding agent to secure the first and second tubular strings together. The crimping step may further comprise compressing the bonding agent between the first and second tubular strings. The bonding agent may be carried on the first tubular string prior to the positioning step. Alternatively, the bonding agent may be carried on the second tubular string prior to the positioning step. The first tubular string may be conveyed downhole prior to conveying the second tubular string downhole. The second tubular string may be conveyed downhole prior to conveying the first tubular string downhole. The conveying step may further comprise conveying the second tubular string through the first tubular string. The conveying step may further comprise conveying the second tubular string through a window formed through a sidewall of the first tubular string.

Preferably, the crimping step further comprises crimping the first and second tubular strings together circumscribing the window. In the conveying step a portion of the second tubular string may remain positioned coaxially within the first tubular string, and wherein the crimping step may further comprise crimping the portion of the second tubular string to the first tubular string.

Ideally, in the conveying step a portion of the second tubular string extends laterally across the first tubular string, and wherein the crimping step further comprises crimping the portion of the second tubular string to the first tubular string. The method may further comprise the step of forming an opening through a sidewall of the portion of the second tubular string, the opening providing fluid communication through the first tubular string, and wherein the crimping step further comprises crimping the first and second tubular strings together circumscribing the opening. Also, the method may further comprise the step of outwardly expanding the second tubular string. The expanding step may be performed by displacing a wedge through the second tubular string. The expanding step may be performed after the conveying step and prior to the

crimping step. The first tubular string may be outwardly expanded. The first tubular string expanding step may be performed prior to the conveying step.

Also described below is a method of forming a connection between first and second tubular strings downhole, the method comprising the steps of: installing the first tubular string in a wellbore; conveying the second tubular string through the first tubular string; outwardly expanding the second tubular string within the first tubular string; and then crimping the first and second tubular strings together, thereby securing the second tubular string to the first tubular string. The second tubular string extends longitudinally outward from the first tubular string, the first and second tubular strings being substantially coaxial, during the crimping step. The method may further comprise the step of bonding the first and second tubular strings together. The bonding step may further comprise positioning a bonding agent between the first and second tubular strings. The crimping step may further comprise compressing the bonding agent between the first and second tubular strings.

The method may yet further comprise the step of sealing the first and second tubular strings together. The sealing step may further comprise forming a metal to metal seal between the first and second tubular strings. The sealing step may further comprise positioning a sealing material between the first and second tubular strings.

The crimping step may further comprise compressing the sealing material between the first and second tubular strings.

Also described hereinafter is a method of forming a connection between first and second tubular strings downhole, the method comprising the steps of: installing the first tubular string in a first wellbore; conveying the second tubular string into the first tubular string; displacing the second tubular string through a window formed through a sidewall of the first tubular string; and then crimping the first and second tubular strings together, thereby securing the second tubular string to the first tubular string.

The crimping step may further comprise crimping an end of the second tubular string to a portion of the first tubular string extending outwardly from the window. In the crimping step, the first tubular string portion may be generally tubular and may outwardly overlap the second tubular string. In the crimping step, the second tubular string may be noncoaxial with any portion of the first tubular string internal to the window. The displacing step may further comprise leaving a portion of the second tubular string extending longitudinally within the first tubular string. The crimping step

may further comprise crimping the second tubular string portion to the first tubular string.

Preferably, the displacing step further comprises leaving a portion of the second tubular string extending laterally across a longitudinal bore of the first tubular string. The crimping step may then further comprise crimping the second tubular string portion to the first tubular string, and may yet further comprise crimping about an opening formed through the second tubular string portion. The second tubular string portion may include a flange circumscribing the opening, and wherein the crimping step may further comprise crimping the flange to the first tubular string.

The method may further comprise the step of outwardly expanding the second tubular string within the first tubular string. The expanding step may be performed after the displacing step and prior to the crimping step. The method may further comprise the step of bonding the first and second tubular strings together. The bonding step may further comprise positioning a bonding agent between the first and second tubular strings. The crimping step may further comprise compressing the bonding agent between the first and second tubular strings. The method may also comprise the step of sealing the first and second tubular strings together. This sealing step may further comprise forming a metal to metal seal between the first and second tubular strings. The sealing step may further comprise positioning a sealing material between the first and second tubular strings. The crimping step may further comprise compressing the sealing material between the first and second tubular strings.

Reference is now made to the accompanying drawings, in which:

FIG. 1 is a schematic cross-sectional view of a first embodiment method of forming a connection between tubular strings downhole, according to the present invention.

FIG. 2 is a schematic cross-sectional view of the first method, wherein further steps of the method have been performed;

FIG. 3 is a schematic cross-sectional view of a second embodiment of a method according to the present invention;

FIG. 4 is a schematic cross-sectional view of a third embodiment of a method according to the present invention;

FIG. 5 is a schematic cross-sectional view of a fourth embodiment of a method according to the present invention; and

FIGS. 6A & 6B are schematic cross-sectional views of a fifth embodiment of a method embodying according to the present invention.

Representatively illustrated in FIG. 1 is a method 10 which embodies principles of the present invention. In the following description of the method 10 and other apparatus and methods described herein, directional terms, such as "above", "below", "upper", "lower", etc., are used only for convenience in referring to the accompanying drawings. Additionally, it is to be understood that the various embodiments of the present invention described herein may be utilized in various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of the present invention.

In the method 10 as depicted in FIG. 1, a tubular string, such as casing string 12, is installed in a wellbore 14, and then another tubular string, such as liner string 16, is conveyed into the wellbore. However, it is to be clearly understood that the casing and liner strings 12, 16 are merely representative of a wide variety of tubular strings which may be used in methods embodying principles of the invention. For example, both of the tubular strings could be casing strings or liner strings, or one or both of the tubular strings could be a production tubing string, etc. Thus, it will be appreciated that the invention is not limited by the specific details of the exemplary method 10 described herein.

The casing string 12 may be an expandable casing string, in which case it may be expanded outward prior to conveying the liner string 16 into the wellbore 14. In the embodiment of the method 10 shown in FIG. 1, the liner string 16 is actually conveyed through the casing string 12, and so it is desirable at this point for the liner string to have an outer diameter which is smaller than an inner drift diameter 18 of the casing string. However, it is not necessary in keeping with the principles of the invention for one tubular string to be conveyed through another tubular string.

The liner string 16 is conveyed through the casing string 12 using a running tool 20 which engages an inner side surface of the liner string. Attached above the running tool 20 is a crimping tool 22, and attached below the running tool is an expansion tool 24. The crimping tool 22 is used in the method 10 in forming a connection between the casing and liner strings 12, 16, as will be described more fully below.

The expansion tool 24 is used to expand the liner string 16 outward after it is properly positioned within the casing string 12. Specifically, the expansion tool 24

includes an actuator 26, such as an electric, hydraulic, mechanical, etc. actuator, which displaces a conically-shaped wedge 28 through the liner string 16 to outwardly expand the liner string. Other expansion devices, such as inflation-type devices, etc., may be used in place of the expansion tool 24 without departing from the principles of the invention.

Preferably, the liner string 16 is expanded within a radially enlarged lower end portion 30 of the casing string 12. In this manner, the liner string 16 may be expanded so that its inner drift diameter 32 is substantially equal to the inner drift diameter 18 of the casing string 12. Preferably, the liner string drift diameter 32 is no less than the casing string drift diameter 18 after the liner string 16 is expanded outward, but it may be smaller without departing from the principles of the invention.

Note that the liner string 16 could be conveyed into the wellbore 14 prior to conveying the casing string 12 into the wellbore. For example, the liner string 16 could be positioned in the wellbore 14 first, and then the casing string 12 could be installed in the wellbore so that the enlarged lower end 30 thereof passes over the upper end of the liner string. In that case, there would be no need to convey the liner string 16 through the casing string 12, and the method 10 would permit a bottom up assembly of tubular strings in the wellbore.

Carried externally on the liner string 16 is a material 34 which may be a sealing material and/or a bonding agent. Alternatively, or in addition, a material 36 may be carried internally on the casing string 12 at its lower end 30. Where the materials 34, 36 are sealing materials, they may be resilient materials, elastomers, nonelastomers, or any other type of sealing material which may be used to form a seal between the casing and liner strings 12, 16.

Where the materials 34, 36 are bonding agents, they may be adhesives or any other type of bonding agent which may be used to secure the casing and liner strings 12, 16 to each other. Of course, one type of material may serve more than one function. For example, an epoxy material, other polymer resin, etc. may serve to seal between the casing and liner strings 12, 16 and to bond the tubular strings together. It is, however, to be understood that the use of the materials 34, 36, or either of them, is not necessary in keeping with the principles of the invention.

Referring additionally now to FIG. 2, the method 10 is representatively illustrated wherein further steps of the method have been performed. The liner string 16 has been

expanded outwardly after its upper end was positioned within the lower end 30 of the casing string 12, so that its drift diameter 32 is now substantially equal to the casing string 12 drift diameter 18. Thus, no substantial restriction to access or flow is presented through the connection between the casing and liner strings 12, 16.

After the liner string 16 was expanded, the crimping tool 22 was used to form multiple crimps 38 in the casing and liner strings. The crimping tool 22 forms the crimps 38 by outwardly displacing multiple dies 40 carried thereon (see FIG. 1). The dies 40 may be displaced outward in the same manner as slips on a packer are displaced outward, or in any other manner well known to those skilled in the art.

The dies 40 may form the crimps 38 as circumferentially extending corrugations, as depicted in FIG. 2, or the dies may be used otherwise in forming the connection between the casing and liner strings 12, 16, such as by forming folds, creases, notches, projections, etc. As used herein, the terms "crimp" and "crimping" are used broadly to designate any such manner in which one or more multiple elements are mechanically formed so that they securely engage each other. In an important aspect of the invention, this forming step is performed after the elements are positioned downhole.

The crimps 38 secure the casing and liner strings 12, 16 together. The crimps 38 may also serve to form a seal between the casing and liner strings 12, 16. For example, a metal to metal seal may be formed when the casing and liner strings 12, 16 are crimped together. Alternatively, or in addition, the materials 34, 36 may be compressed between the casing and liner strings 12, 16 when the crimps 38 are formed. If the materials 34, 36, or either of them, are a bonding agent, this compression between the casing and liner strings 12, 16 may serve to further secure the tubular strings to each other.

After the crimping step, cement 42 is flowed into an annulus 44 between the wellbore 14 and the casing and liner strings 12, 16. The relatively low outer profile of the connection between the casing and liner strings 12, 16, and the minimal, if any, inner restriction provided by the connection enhances the efficiency of the cementing operation. Other subsequent operations, such as production operations, are similarly enhanced by the connection provided by the present invention.

Referring additionally now to FIG. 3, another method 50 embodying principles of the invention is representatively illustrated. In the method 50, a casing string 52 is installed in a parent wellbore 54 either prior to or subsequent to drilling a branch

wellbore 56 intersecting the parent wellbore. The casing string 52 as depicted in FIG. 3 includes a window 58 formed through a sidewall thereof. The window 58 may be formed before or after the casing string 52 is installed in the wellbore 54.

The casing string 52 also includes a generally tubular flange 60 extending outward somewhat from the window 58. A liner string 62 is conveyed through the casing string 52, and outward through the window 58 into the branch wellbore 56. An upper end of the liner string 62 is positioned within the flange 60, and the upper end of the liner string is crimped to the flange 60, for example, using a crimping tool such as the crimping tool 22 described above.

As depicted in FIG. 3, only one crimp 64 has been formed, but multiple crimps may be formed as desired. The crimp 64 circumscribes the window 58. The crimp 64 may be formed prior to milling off an upper end of the liner string 62 extending into the interior of the casing string 52, to thereby stabilize the liner string during the milling process.

Alternatively, the upper end of the liner string 62 may be preformed so that it does not extend significantly into the casing string 52 during the crimping step (as depicted in FIG. 3), and no milling process may be necessary. In that case, the liner string 62 would be noncoaxial with any portion of the casing string 52 internal to the window 58 during the crimping step.

The crimp 64 may form a seal between the casing and liner strings 52, 62, for example, by forming a metal to metal seal therebetween. Alternatively, or in addition, materials such as the materials 34, 36 described above may be used to seal between the casing and liner string 52, 62 and/or to secure the tubular strings together.

The liner string 62 may be an expandable liner string, in which case it may be expanded as described above for the liner string 16. For example, the liner string 62 may be expanded outward after it is positioned in the branch wellbore 56 with its upper end within the flange 60. The casing string 52 could also be expandable, in which case it is preferably expanded outward prior to conveying the liner string 62 through the casing string.

Referring additionally now to FIG. 4, another method 70 embodying principles of the invention is representatively illustrated. In the method 70, a casing string 72 is installed in a parent wellbore 74 either prior to or subsequent to drilling a branch wellbore 76 intersecting the parent wellbore. The casing string 72 as depicted in FIG. 4

includes a window 78 formed through a sidewall thereof. The window 78 may be formed before or after the casing string 72 is installed in the wellbore 74.

A liner string 82 is conveyed through the casing string 72, and outward through the window 78 into the branch wellbore 76. An upper end of the liner string 82 is positioned longitudinally and coaxially within the casing string 72 above the window 78, and the upper end of the liner string is crimped therein, for example, using a crimping tool such as the crimping tool 22 described above.

As depicted in FIG. 4, only one crimp 84 has been formed, but multiple crimps may be formed as desired. The crimp 84 may form a seal between the casing and liner strings 72, 82, for example, by forming a metal to metal seal therebetween. Alternatively, or in addition, materials such as the materials 34, 36 described above may be used to seal between the casing and liner strings 72, 82 and/or to secure the tubular strings together.

The liner string 82 may be an expandable liner string, in which case it may be expanded as described above for the liner string 16. For example, the liner string 82 may be expanded outward after it is positioned in the branch wellbore 76 with its upper end within the casing string 72. The casing string 72 could also be expandable, in which case it is preferably expanded outward prior to conveying the liner string 82 through the casing string.

To provide access and/or fluid communication through the casing string 72, one or more openings 86 may be formed through a sidewall of the liner string 82 where it extends laterally across an internal longitudinal flow passage 88 of the casing string. The opening 86 may be formed through the liner string 82 sidewall after the liner string is conveyed into the branch wellbore 76, for example, after the crimp 84 is formed, or the opening may be preformed in the liner string prior to conveying it into the well.

Referring additionally now to FIG. 5, another method 90 embodying principles of the invention is representatively illustrated. In the method 90, a casing string 92 is installed in a parent wellbore 94 either prior to or subsequent to drilling a branch wellbore 96 intersecting the parent wellbore. The casing string 92 as depicted in FIG. 5 includes a window 98 formed through a sidewall thereof. The window 98 may be formed before or after the casing string 92 is installed in the wellbore 94.

A liner string 102 is conveyed through the casing string 92, and outward through the window 98 into the branch wellbore 96. An upper end of the liner string 102 is

positioned longitudinally and coaxially within the casing string 92. The upper end of the liner string 102 may be secured and/or sealed to the casing string 92 using one or more crimps 103, similar to the crimp 84 in the method 70 described above.

The liner string 92 includes a generally tubular flange 100 extending downward somewhat from an opening 106 formed through a sidewall of the liner string 102 where it extends laterally across an inner longitudinal flow passage 104 of the casing string 92. The flange 100 and opening 106 may be formed before or after the liner string 102 is conveyed into the well.

The flange 100 is crimped to the casing string 92, for example, using a crimping tool such as the crimping tool 22 described above. As depicted in FIG. 5, only one crimp 108 has been formed, but multiple crimps may be formed as desired. The crimp 108 extends circumferentially about the opening 106, so that it circumscribes the opening.

The crimp 108 may form a seal between the casing and liner strings 92, 102, for example, by forming a metal to metal seal therebetween. Alternatively, or in addition, materials such as the materials 34, 36 described above may be used to seal between the casing and liner string 92, 102 and/or to secure the tubular strings together. The crimp 108 may be formed before, after, or at the same time as the crimp 103.

The liner string 102 may be an expandable liner string, in which case it may be expanded as described above for the liner string 16. For example, the liner string 102 may be expanded outward after it is positioned in the branch wellbore 96 with its upper end within the casing string 92. The casing string 92 could also be expandable, in which case it is preferably expanded outward prior to conveying the liner string 102 through the casing string.

Referring additionally now to FIGS. 6A & B, another method 110 embodying principles of the invention is representatively illustrated. In the method 110, a casing string 112 is installed in a parent wellbore 114 either prior to or subsequent to drilling a branch wellbore 116 intersecting the parent wellbore. The casing string 112 as depicted in FIG. 6A includes a window 118 formed through a sidewall thereof. The window 118 may be formed before or after the casing string 112 is installed in the wellbore 114.

A liner string 120 is conveyed through the casing string 112, and outward through the window 118 into the branch wellbore 116. An upper end of the liner string

120 is positioned longitudinally and coaxially within the casing string 112 above the window 118.

A running tool (not shown) for the liner string 120 engages an orienting profile 122 in the casing string 112. The orienting profile 122 rotationally orients the liner string 120 so that an opening 124 formed laterally through a sidewall of the liner string is aligned with an inner longitudinal bore 126 of a deflection device 128 positioned in the casing string 112 below the window 118. The deflection device 128 is used to deflect the liner string 120 from the parent wellbore 114 into the lateral wellbore 116 via the window 118 as the liner string is lowered in the casing string 112.

The opening 124 provides access and/or fluid communication through the casing string 112 where the liner string 120 extends laterally across an internal longitudinal flow passage 136 of the casing string. The opening 124 may be formed through the liner string 120 sidewall after the liner string is conveyed into the branch wellbore 116, or the opening may be preformed in the liner string prior to conveying it into the well.

When the liner string 120 is properly positioned in the lateral wellbore 116 with the upper end of the liner string in the casing string 112 above the window 118, and with the opening 124 aligned with the bore 126 of the deflection device 128, a liner hanger 130 attached to the upper end of the liner string is set in the casing string. The liner hanger 130 anchors the liner string 120 in position and seals between the liner and casing strings. Alternatively, one or more crimps could be used for this purpose, such as the crimp 84 in the method 70 described above.

The liner string 120 may be expandable, in which case it would preferably be expanded outward after it is properly positioned. Expansion of the liner string 120 may be accomplished by means of the running tool used to convey the liner string into the well, or another tool may be used to expand the liner string. The casing string 112 could also be expandable, in which case it is preferably expanded outward prior to conveying the liner string 120 through the casing string.

A generally tubular sleeve 132 is then inserted through the opening 124 and into the bore 126 of the deflection device 128 from within the liner string 120. The sleeve 132 includes an upper radially outwardly extending flange 134 which is shaped to conform to the interior of the liner string 120 about the opening 124. If the liner string 120 is expandable, then preferably the liner string is expanded prior to inserting the sleeve 132 through the opening 124.

A seal 138 may be carried externally on the sleeve 132 for sealing engagement with the bore 126 of the deflection device 128. The seal 138 may be any type of conventional seal, such as o-rings, packing, etc., or the seal may be a sealing and/or bonding material similar to the materials 34, 36 described above. The sleeve 132 may be expandable, in which case the seal 138 may be compressed between the sleeve and the deflection device 128 in the bore 126 when the sleeve is expanded outward.

An anchoring device 140 may be attached to the sleeve 132 for securing the sleeve in position in the deflection device 128. For example, the anchoring device 140 may be a RatchLatch® available from Halliburton Energy Services, Inc. of Houston, Texas. The anchoring device 140 preferably permits the sleeve 132 to be inserted into the bore 126, but prevents the sleeve from being withdrawn from the bore.

As depicted in FIG. 6B, the sleeve 132 has been inserted into the bore 126 sufficiently far, so that the upper flange 134 contacts the interior surface of the liner string 120 about the opening 124. If provided, the seal 138 may now be sealingly engaged within the deflection device 128, and the anchoring device 140 may secure the sleeve 132 in position, so that the flange 134 remains in contact with the interior surface of the liner string 120 about the opening 124.

If the sleeve 132 is expandable, then preferably it is expanded outward after it is positioned in the bore 126 of the deflection device 128. This expansion of the sleeve 132 may be used to bring the seal 138 into sealing engagement with the bore 126. Expansion of the sleeve 132 may be accomplished using the running tool used to convey the liner string 120 into the well, or another expansion tool may be used, such as the expansion tool 24 described above.

To secure and/or seal the sleeve 132 within the deflection device 128, one or more crimp(s) 142 may be formed in the sleeve and deflection device. The crimp 142 may be used in place of, or in addition to, either of the seal 138 and the anchoring device 140. If the seal 138 is used, the seal may be compressed between the sleeve 132 and the deflection device 128 when the crimp 142 is formed. A metal-to-metal seal may be formed between the sleeve 132 and the deflection device 128, for example, if the seal 138 is not used.

The crimp 142 may be formed by the running tool used to convey the liner string 120 into the well, or another crimping tool may be used, such as the crimping tool 22 described above. Note that the crimp 142 is not necessary, since the seal 138 and

anchoring device 140 may perform the functions of securing and sealing the sleeve 132 in the deflection device 128. However, any combination of the crimp 142, the seal 138 and the anchoring device 140 may be used in keeping with the principles of the invention.

One or more crimp(s) 144 may be used to secure and/or seal the flange 134 to the liner string 120 about the opening 124. The crimp 144 extends circumferentially about the opening 124 and, thus, circumscribes the opening.

A sealing and/or bonding material, such as the materials 34, 36 described above, may be used between the flange 134 and the inner surface of the liner string 120. If such a material is used, it may be compressed between the flange 134 and the inner surface of the liner string 120 when the crimp 144 is formed. A metal-to-metal seal may also, or alternatively, be formed between the flange 134 and the inner surface of the liner string 120 when the crimp 144 is formed.

Of course, a person skilled in the art would, upon a careful consideration of the above description of representative embodiments of the invention, readily appreciate that many modifications, additions, substitutions, deletions, and other changes may be made to these specific embodiments, and such changes are contemplated by the principles of the present invention. For example, in the method 50 described above, the flange 60 could be formed on the liner string 62, instead of being formed on the casing string 52.

CLAIMS

1. A method of forming a connection between first and second tubular strings downhole, the method comprising the steps of: installing the first tubular string in a first wellbore; conveying the second tubular string into the first tubular string; displacing the second tubular string through a window formed through a sidewall of the first tubular string; displacing a structure through an opening in a sidewall of the second tubular string; and sealing the structure between the second tubular string and the first tubular string.

2. A method according to Claim 1, wherein in the structure displacing step a portion of the second tubular string is positioned within the first tubular string.

3. A method according to Claim 2, wherein in the structure displacing step the second tubular string portion is generally coaxial with the first tubular string.

4. A method according to Claim 1, wherein the structure displacing step further comprises displacing the structure into a deflection device positioned in the first tubular string.

5. A method according to Claim 4, wherein the sealing step further comprises sealingly engaging the structure in a bore of the deflection device.

6. A method according to Claim 4, wherein the sealing step further comprises crimping the structure to the deflection device.

7. A method according to Claim 4, wherein the sealing step further comprises compressing a sealing material between the structure and the deflection device.

8. A method according to Claim 4, wherein the sealing step further comprises positioning a sealing material between the structure and the deflection device.

9. A method according to Claim 4, wherein the sealing step further comprises

forming a metal to metal seal between the structure and the deflection device.

10. A method according to Claim 4, further comprising the step of anchoring the structure to the deflection device.

11. A method according to Claim 10, wherein the anchoring step further comprises crimping the structure to the deflection device.

12. A method according to Claim 10, wherein the anchoring step further comprises forming a gripping engagement between the structure and the deflection device using an anchoring device.

13. A method according to Claim 10, wherein the anchoring step further comprises positioning a bonding agent between the structure and the deflection device.

14. A method according to Claim 10, wherein the anchoring step further comprises crimping the structure to the second tubular string.

15. A method according to Claim 4, wherein the structure is generally tubular with a radially enlarged flange, and wherein the structure displacing step further comprises engaging the flange with the second tubular string about the opening.

16. A method according to Claim 15, wherein in the engaging step the structure flange is complementarily shaped relative to an interior of the second tubular string about the opening.

17. A method according to Claim 15, wherein the engaging step further comprises sealing the flange to the second tubular string about the opening.

18. A method according to Claim 17, wherein the flange sealing step further comprises crimping the flange to the second tubular string.

19. A method according to Claim 17, wherein the flange sealing step further

comprises compressing a sealing material between the flange and the second tubular string.

20. A method according to Claim 17, wherein the flange sealing step further comprises positioning a sealing material between the flange and the second tubular string.

21. A method according to Claim 17, wherein the flange sealing step further comprises forming a metal to metal seal between the flange and the second tubular string.

22. A method according to Claim 15, further comprising the step of anchoring the flange to the second tubular string.

23. A method according to Claim 22, wherein the anchoring step further comprises crimping the flange to the second tubular string.

24. A method according to Claim 22, wherein the anchoring step further comprises positioning a bonding agent between the flange and the second tubular string.

25. A method according to Claim 1, further comprising the step of expanding the structure after the structure displacing step.

26. A method according to Claim 25, wherein the expanding step further comprises expanding the structure within a deflection device positioned in the first tubular.

27. A method according to Claim 25, wherein the expanding step further comprises compressing a sealing material against the structure.

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Application No: GB0517605.2 **Examiner:** Brendan Churchill

Claims searched: 1-27 **Date of search:** 1 November 2005

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-5, 7-10, 12, 25-27	EP 0961007 A2 [HALLIBURTON] Note especially figure 4B, and paragraphs [0113-0116] & [0119-0122]
X	1-3, 25, 27	GB 2333544 A [HALLIBURTON] Note especially figure 19, page 20 line 24 to page 21 line 25, and page 22 line 16 to page 23 line 23
X	1-4	GB 2333543 A [HALLIBURTON] Note especially figures 2 & 3, and claims 19 & 20

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

E1F

Worldwide search of patent documents classified in the following areas of the IPC[07]

E21B

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI